Salomons, Sir D.L.
A new method of signalling on railways.

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A

NEW METHOD

OF

Signalling on Railways.

Invented and Patented by

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PREFACE.

WE might indeed ask ourselves "is there such a thing as the future?" The present merges instantaneously into the past; and when we look back upon events which have occurred during our lifetime, it is hard to realise them in all their pristine force. They appear to us as mere dreams.

Marvellous indeed must be the organization of man, seeing that he can act on the spur of the moment, which is gone like a flash of lightning.

However distressing the rapid passage of time may be to us on reflection, yet it only shows the vital importance of never losing time—which is not money, according to the old saying, but life. Time brings us nearer to death; and, death once reached, ends our efforts on this earth for ever.

Why do I begin thus, when my present intention is merely to further explain "A New Method of Railway Signalling?" To draw attention to the impossibility of maturing one's thoughts at once, in years, in a life-time!

Being only human, I must at once admit that since writing my last pamphlet on Signalling, dated Nov. 6th, 1874, I have discovered that many portions of my system are capable of improvement.

Although my patent was taken out in 1874, it was as early as 1868, if not before, that this mode of signalling suggested itself to me. The object of the following few pages is not to explain the system very fully, but to show how it would be carried out in practice; in fact, a handbook from which an engineer could easily see the practical details of the new method, and appreciate the numerous modifications of which it is capable. The models referred to in my last pamphlet have been finished and exhibited. They have quite fulfilled my expectations, although they will bear considerable improvement; as, in my opinion, "a thing worth doing at all is worth doing well;" and I shall not rest until they approach perfection. No sooner have we done a thing than we wish it could be commenced afresh, under the more favourable auspices of the knowledge we have gained by experience.

The hardship is that all small models, however perfect, possess certain disadvantages which disappear in the full size machines; and I have to thank those who saw the models of my system, for showing me so much indulgence in this respect. Yet the models illustrated the automatic signalling exceedingly well. It is my wish to exhibit them again in a much more perfect form, on some future occasion.

This pamphlet contains a large portion of the first one which has been carefully revised. Several parts have been added, detailing at greater length many portions of the system which, in the first pamphlet, were merely referred to in the appendix. The following pages are divided into 10 Parts:—

PART 1.—Electricity and Electrical phenomena.
,, 2.—Description of the "Central Rail system."
,, 3.—Testing, as applied to "Central Rail system."
,, 4.—Remarks on "Central Rail system."
,, 5.—The "Wire System," and the modes of testing the same.
,, 6.—An explanation of the Plates.
,, 7.—Remarks upon the "Wire system."
,, 8.—General observations.
,, 9.—The disadvantages of the Block system.
,, 10.—Working Expenses.

It may be remarked that Part I. is appended for the benefit of those who are unacquainted with the science of electricity, and is merely intended to be a brief sketch of the subject. Parts II., III., and IV. deal with the "Central Rail system." Part V. describes the New system, as I propose to employ it in practice.

A New Method of Signalling on Railways.

INTRODUCTION.

IT is many years since I was struck by the numerous disadvantages which exist in the present mode of signalling on railways. In the block system, which is now universally considered to be the best (except in particular situations), we have human attention and labour, electricity, and many complicated mechanical contrivances, all called into operation at once; and, for safety, every one of these must work harmoniously together.

It is not the intention here to describe concisely the present methods of signalling, because it is assumed that the reader is already acquainted with them: notwithstanding which a passing glance will be taken at the "block system."

We all know that mortals are liable to err, especially when much tried. On the contrary, we seldom find electrical arrangements fail, unless associated with intricate mechanism. Lastly, all machinery, however faultless, must constantly be watched, oiled, and kept in good order, to secure its perfect action. Advancing a step further: The eyesight is at present the only means of distinguishing the different signals, but is not reliable when the brain is tired from any cause. Then, also, during foggy and misty weather, sound signals must be used, and these are very inconvenient, according to the present method. At night, lights are now employed: in valleys, mists

often suddenly arise at sunset and sunrise, whereby the signals are hidden, at these times, to trains passing by; and when sufficient notice has not been given for the procuring of fog signals, accidents are almost certain. Also, there is the possibility of a lamp going out, because of want of oil, bad wick, wind or rain; even the whole semaphore apparatus might be blown down, or struck by lightning. In all cases where there are many lines the signals become so numerous as to be confusing. We all know how dangerous level crossings are; the same may be said of facing points. When the harmonious-system is resorted to, the disposition of the levers is complicated, and therefore very liable to get out of order unless constantly looked after.

Before going on, it may be well to briefly explain the terms, "semaphore," "block-system," "facing-points," and "harmonious-system."

A semaphore is the arm which is raised to the horizontal for "danger," and lowered to the vertical, (when it is generally sheathed by its post,) for "safety." On some lines "safety" is indicated by only lowering the arm forty-five degrees. Sometimes, half down means "proceed with caution"; and quite down, "safe." The former signal, I believe, is now abandoned; so that a train must in all cases either "go on" or "stop."

In the "block" system, the line is divided into lengths, called "blocks,"—say, for example, of two miles each. At every point where one "block" ends and another commences, there is a set of signals, the signal-boxes being connected one with the other by telegraphic intercommunication. The method of working is simple enough. A train enters a block; the signal-man here then sets his signal at "danger," to stop all coming trains on that line; he also telegraphs to the signal-boxes nearest to his on either side, each being a "block distance" from him. The signal-man, where the train *has* passed, now knows it has safely left that block, so that he again sets his signal, this time at "safe," to let the next train pass. The signal-man in front is informed that a train may be expected; when it arrives, he repeats the same process; and so on. Thus only one train can be in a block at a time,

"Facing-points" are those where a train may be transferred from one line to another, without "backing" first.

The "harmonious system" is a mechanical arrangement whereby no dangerous combination of signals can be set where there are crossings or many "points."

The foregoing explanatory remarks have been inserted, in order that a general idea of the present methods of signalling on railways may be understood, before describing the one now proposed for introduction.

It was not till the newspapers almost daily brought accounts of serious railway accidents, rather more than two years ago, that my serious attention was given towards improving upon our present methods of signalling. I had thought of a plan long before, which, till then, remained only in embryo. From this time I conducted many experiments, and spent much time in thinking the matter out: and now I am enabled to place before the public a system, which if not absolutely perfect—excuse the conceit of an inventor, if he says—is the very next door to it. I confidently challenge any one to show any serious flaw in the system, although possibly some points may be modified with advantage.

PART I.

ELECTRICITY.

WHATEVER electricity in any body may be, I shall speak of it as if it were a fluid, although there is little doubt that it is merely the result of a peculiar state of the atoms or molecules of the body, perhaps somewhat analogous to heat; yet it is convenient to speak of it as a fluid.

It is only proposed to describe the subject of electricity so as to enable the reader to understand what will be said hereafter, and consequently, a host of important facts will be omitted.

Electricity may be produced by friction, chemical action, or heat. In theory these three modes might be reduced to one. It is the second method of production which will engage our attention.

The electricity produced in this manner will circulate as a current in any conductor—*i.e.*, a substance capable of being traversed by the fluid from one point to another, such as a wire, for metals are good conductors. Although we divide substances into conductors and non-conductors, yet no material is found to be perfect in either of these properties.

In every case where a current is required to circulate, the circuit must be "complete" or "closed," which means that the current must be allowed to travel an entire circle.

It will be sufficient for my purpose to explain one form of *cell* for the production of electricity by chemical means, viz., the *Leclanché cell,* so called after the inventor.

There is a glass vessel, containing water and sal-ammoniac, also a bar of zinc; in this vessel is placed a porous jar, containing pounded carbon, mixed with the needle-form binoxide of manganese; in this mixture is deposited a piece of gas-carbon. Attached to this latter is a wire, and one likewise to the bar of zinc. When these wires are placed in contact, the circuit is "closed," and a current passes. Many of these cells may be employed to act together, the combination being termed a "battery." It is not necessary that the circuit shall be a wire—*any* conductors will do, such as a series of metallic blocks or bars touching each other. Glass, shellac, ebonite, gutta-percha, silk, are pre-eminently non-conductors.

The earth may be employed to complete the circuit. Suppose, instead of putting the wires in contact, as we did above, they are buried in the ground, or placed in contact with some conductors which are well connected with the earth, then a current is found to pass as before. When a wire is so treated, it is said to be "put to earth." This term will frequently be employed hereafter.

Now, instead of letting the current pass through a wire, straight or bent to a circle, suppose it is wound round and round so as to form a hollow coil. In this case, since the fluid would jump across the turns of the wire (because these touch each other), instead of passing through the whole length of it as required, it is necessary to "insulate" such wire, by giving it a coating of gutta-percha, or a covering of silk, these not affording a passage to the current. If a magnetic needle is balanced on a point or pivots in the centre of this hollow coil; it is found, when a current is allowed to pass, that this needle is deflected to one side or the other, according to the direction in which the current is flowing. To explain the laws of deflection, a few words must be said on the varieties of electricity.

Two sorts are found to exist: one is called positive (+), and the other negative (—). The current flowing through the wire from the zinc, in the cell, is of the negative description; that flowing from the carbon is positive. They are

easily distinguished: for objects electrified similarly repel* one another, while if charged differently they attract one another, and with more vigour than an electrified substance will attract a material in a non-electric state.

The law of the deflection of the magnetic needle will now be understood; for, supposing a person to be swimming in the wire with the positive current, *facing* the needle, its north pole (*i.e.*, the end which points towards the north when balanced horizontally) will always deflect to the left hand.

Suppose we have two insulated wires, each wound into a coil—one wound in the contrary direction to the other—these two coils so placed end to end as to form in appearance only one; also, each separately capable of influencing a magnetic needle placed in their centre. Now, passing a positive current through one coil will cause the needle to deflect; then passing the same current through the other coil, the aforesaid phenomenon will occur, only in the opposite direction, because the wire is wound the contrary way. I shall speak of such an instrument as the "*indicator*," when describing my new plan of signalling in the next part.

Again: let us take a piece of soft iron, bent to the form of a horse-shoe, and round one leg wind a piece of insulated wire; then continue winding on the other leg, so that we have both surrounded by coils, each coil being a continuation of the other, so that there are but two ends to the wire. Now for so long *only* as a current is permitted to pass through the wire, so long is this horse-shoe a magnet. Such an arrangement is termed an electro-magnet. It is necessary that the iron should be soft, otherwise the magnetizing would become permanent.

There is, even in the best conductors, always a resistance to the passage of the electric fluid, which is of extreme importance in practice, although there are many disadvantages attaching to it. The metals vary considerably in their conductive properties, silver and copper ranking foremost. Taking any substance, the resistance increases as the cross section of the material is diminished in area, all other things being equal. The battery also possesses a considerable resistance.

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* Or appear to repel one another.

That of the battery is called "internal resistance;" and of the outside circuit, "external resistance."

When a battery polarises quickly—*i.e.*, soon ceases to give electricity, unless it is allowed a rest, or shaken, as in the Leclanché—considerable *external resistance* is necessary when a current is required for any length of time, in order to prevent the electricity from travelling too rapidly. The reader need not be troubled here with the various causes of polarisation, and the remedies, beyond being informed of the fact; nor will this phenomenon trouble us in the new system.

The Leclanché has many advantages over other forms of *cells*; it will work for a very long period without recharging, it produces a large amount of electricity, and has a small internal resistance.

Now we may at once plunge into our true subject.

PART II.

CENTRAL RAIL SYSTEM.

IN this part will be described one new method proposed for signalling on railways, viz:—the Central Rail method; and from what has previously been said, probably any person of ordinary intelligence will understand the following explanation perfectly.

When describing a subject which is new, it is always advisable to employ some systematic method for making it clear: such a course will now be adopted.

THE RAIL AND SIGNALS.*

To state the whole system briefly, would be to say, "every engine shall be a signal in itself." To make it obvious how this can be effected, the line will first be described.

In addition to the present pair of rails, a third would be necessary, and this one insulated. It might be iron, with an oblong section, of $\frac{1}{4}$ inch by 1 inch; so small, since there would be no strain whatever upon it. When laid, it would stand up as a small girder (see fig. 9) 1 inch deep. This would be supported on "chairs," and must be slightly raised above the ground. The present "sleepers" would be the fixing points for these "chairs." The rail would have small pieces of ebonite at its sides and below, which might be fixed to it, but only in those places where the "chairs" form supports. Imagine such a rail placed in position; then, to "tighten up,"

* See Part V. for the most practical modification of the system.

wooden wedges would be driven in on one or both sides of the rail, where the "chairs" are, and one below, which could raise it up, if at any time it were to sink. The pieces of ebonite on the rail would be protected from the weather by pieces of zinc as shown in fig. 9. The rails might be "fish-tailed" one with the other. In describing this system minutely, it is not to be understood that this is the only way of carrying it out; they are so numerous, that a large volume could be filled in describing them. The intention is only to demonstrate two methods, so as to make the general manner of using this system clear.

This line is laid in blocks, every block overlapping the last one; which is accomplished thus: Where one ends and the next begins, instead of simply cutting the rail at this point, so as to make it discontinuous, the rail of the block in front continues, having formed a crook first, side by side with the line of the last block, although not in contact with it. The drawing (fig. 1) shows this clearly, and represents a few complete blocks. The overlapping portion would be considerably longer than the distance required to stop a train going at a very high speed. In future, the overlapping piece from the crook will be spoken of as the "Battery signal line," and the other portion of rail as the "Indicator signal line." It will be seen that this rail is always in a straight line, except the crooked portions which run by the side, parallel to the system.

Under each engine are two metal wheels borne on one axis, which is supported by springs pressing downwards. These wheels are insulated one from another, by one or other of the numerous methods now in practice, and the distance between them is the same as between the "indicator signal line," and the "battery signal line. Wire brushes might be employed to replace the signal wheels, which are very perfect in practice.

Facing the direction in which the train is going, on arriving at the termination of one block and commencement of the next, one wheel (the left hand one) will roll on the "indicator signal line," while the other (the right hand one) will roll on the "battery signal line;" but at other places the left-hand wheel will be free. To avoid a shock when it suddenly runs on or off the "indicator signal line," this latter is wedged off to nothing at its commencement, and rounded at the crooked end.

The engine carries several pieces of apparatus, but to commence, I will only suppose there is a battery and an electric bell.

One wire from the battery, and one from the electric bell are taken to "earth," by being simply attached to the engine, so that the current can pass through the latter to the ordinary railway lines which are connected with the ground. The other wire of the battery is in connection with the right-hand wheel, and is insulated from the engine. The second wire from the electric bell, also insulated from the machine, is connected with the left-hand wheel. The wheels just referred to are the *signal wheels* spoken of above. Now suppose a train to be in a "block," then the right-hand wheel is upon the line, and as this is attached a battery wire. One wire from the battery goes to earth, but since the other is now, (through the signal wheel,) in connection with the insulated line, no current can pass, unless this rail is "put to earth." Imagine another train to enter this block; of course it must somehow be signalled to stop, or a collision will ensue. How is this to be done? Nothing simpler! The electric bell on this engine immediately rings, so long as there is a train in the block it is about to enter, and the driver must pull up his train until it ceases ringing.

The reason for this is—the indicator signal wheel of the second engine is at the commencement of a block on the "indicator signal line," and being connected with "earth" by the wire which passes first to the bell, then to "earth," affords the means of putting the front block line to "earth," and therefore completes the circuit of the battery on the engine in front, (whose battery-signal wheel is on the rail,) and also causes the bell to ring on the train behind. Morever, this train which has been signalled to stop, has control over all the block it has just run over, because its battery signal wheel remains on the line of this block; so if another train were to enter behind this one, *its* bell would announce a train in front, and so on all down the line. It may also be seen why the overlaps should be of considerable length, so that control may always be maintained over the block just passed over, notwithstanding the distance the train has run in pulling up. Later on, a means of stopping the train automatically, when signals are adverse, will be described. All the above is made clear when the diagram is referred to. From what has been said, it is

evident that every front train has control over a train behind which is all that is ever required.

The invention, however, does much more than this. An *indicator* such as has been before described, is also employed; one coil in it being placed in the circuit of the battery signal wheel, and the other in that of the indicator signal wheel, so that when a current passes, the needle deflects right or left, according to which circuit has a current passing through it. Upon consideration of what has been detailed, the deflection of the needle is to one side or the other, according as a train is in the block in front, or entering the block behind. But suppose both these events occur at once, then the needle will attempt to be deflected both ways at the same time, which is impossible, and therefore will either remain stationary, or move *slightly* to one side or the other, if the currents in the coils are not quite equal. It is then very easy to detect the signal, for *ordinarily*, when the needle is at rest, it means "safe," but when at rest by reason of a train in the block in front, and one *waiting* to enter the block behind, the bell is ringing, so no confusion can arise. The needle of the indicator on turning to the right or left, strikes against a bell, the right one having a different tone from the left. Of course a lever on the arbor carrying the needle, or other arrangement might easily effect this end. This indicator might have a dial marked below "SIGNALS": on the left-hand "TRAIN BEHIND": at the right side "TRAIN IN FRONT"; and at the point where the needle stands when at rest, "BELL RINGING, TRAIN BEHIND AND IN FRONT." The magnetic needle would be slightly weighted to keep it vertical, as in an ordinary "detector." In such instruments I have never noticed any unsteadiness in the needle whilst in a train, but if this were found to be the case, it might be overcome by two small spiral hair-springs attached to the needle arbor by their centre ends, their other ends to fixed points, so as to be opposed to each other when in action. Indeed, this indicator is really not wanted for ordinary signalling, except that it is well to have two strings to our bow, so that if from any cause, the current were weak, or the electric bell did not act, then the indicator would be most necessary; but these contingencies are never likely to occur.

It might be mentioned that before the wheels will be a guard, to remove any material which may lie upon the line, and to protect the wheels from damage. Other points worth

mentioning are these,—all the wear on the insulated rail arises from *slight* downward pressure, and not a portion of the engine's weight. The wheels moreover are flat, so that this line may be expected to last three or four times as long as the rails upon which the trains run, although the wedges might occasionally want replacing.

Where crossings for persons and carriages exist, it will be found necessary, as is now commonly done, to raise the level of the ground up to that of the rails, with a border of stone next to them ; or any other convenient protection could be employed. Where the line is likely to be flooded at certain times of the year, the old semaphores could be left at these places, for the plan detailed for signalling will not act under water, unless considerably modified. Even where floods occasionally occur, the insulated rail might be above or at the side of the train, instead of below, and an apparatus on the engine could be made to run on it. The underneath and sides of the line might be dipped in asphalt, which is a non-conductor, and could then even partly lie in water without affecting the system. But if the roads are drained, as they should be, and generally are, no trouble on this head can arise. Again ; no sufficient amount of rust will ever form upon the line to have a deleterious effect ; the passing of trains being frequent, together with the pressure of the wheels upon the line, would soon remove any which might form, and even if a little did, the effect would be only slightly to increase the already small resistance of the circuit.

ACCESSORIES.

Hitherto no explanation has been given of the electric bell ; so, before advancing further, a short description may be added with advantage. It is made thus : An electro-magnet, already described, has an armature before it, borne on a spring in such a manner that it is drawn away from the magnet poles or ends ; to this also is fixed a wire, carrying a weight to strike the bell. There is another spring, which presses the armature towards the magnet poles, yet not sufficient to push it against them. One end of the wire passing round the magnet goes at once to the left-hand signal wheel, whereas the other is attached to the armature spring, and the current then traverses the armature to the other

spring, thence to "earth," thus completing the circuit, when a train is in front, because *its battery* signal wheel is on the line, which goes to the battery, whose other pole is "put to earth." Hence, the moment a current passes, the electro-magnet becomes magnetised, and the armature is drawn towards it, at the same time giving the bell a strike with the hammer attached to it. But the armature now being drawn from contract with the spring pressing it, the current ceases to pass; then by the spring of the armature it is restored to its former position, when the same thing is repeated again and again, producing a vibratory ringing.

In demonstrating a few of the properties of electricity in Part I., it became necessary to approach so closely to the "Indicator," that is was thought best to describe it at that time; it will, therefore, be unnecessary to repeat the description. We shall now go on to some very important *accessories*.

There might be an arrangement by which every signal could be marked on paper, in the following simple manner. The arbor in the indicator would have one lever pen, or more if desired: attached to it, would be some marking instrument, such as is used with the telegraphic "Morse," or even there might be a small apparatus on the same principle as the "Morse" itself, placed in the circuit. A piece of clockwork would always advance a slip of paper at a certain regular rate, *i.e.*, a fixed number of inches per hour; so that the time when any signal was given, could at once be ascertained, by measuring the distance of the mark made by the signal from the end of the strip of paper. A convenient method would be to have the the paper marked at every $\frac{1}{4}$ inch with a red dot; then the distance from one dot to another represents a stated interval of time. Danger signals would, of course, be the only ones reported; and, in addition, the apparatus would be so contrived that, so long as the engine is stopping, a line is being drawn upon the paper. The "signal-marks" and the "stopping line" on the paper would be side by side. Likewise during the time "danger" is set—*i.e.*, the bell is ringing on the engine—the pen is marking on the paper, consequently a line will be formed here also. These lines could be black, to contrast with the red "time dots."

The clockwork can be made to show at what time the train was started from its first station: then we have a test as

to whether it left punctually. To show the use of this arrangement in practice: when the train arrives at its destination, the station-master will unlock the box on the engine, in which the mechanism is situated, and tear off the piece of paper which has passed through during the journey. He can then ascertain the following facts :

1. If the train started at the proper time.
2. How many times danger signals were given *en route.*
3. If these were obeyed: for in every case the length of the "danger line" on the paper should equal the "stopping line," and shows that the engine waited whilst the danger signal lasted.
4. How long a train stopped at any station, because here a stopping line only will be seen.
5. Whether time was lost on the road, and where; also, the precise time of day, when this occurred.
6. When any irregularity occurs, with whom the fault lies.

By keeping this portion of the apparatus under lock and key, no one can tamper with it, and the proper authorities can depend on the register kept being a correct one.

The mode of producing the "Stopping line" is simply to shut off the steam. The lever for accomplishing this will cause a pen to mark the moving paper when the former is in a position for the steam to be turned off. The clock-work, just spoken of, might be made self-acting, either by allowing the engine, while going, to keep it wound up, or what would be better still, by having a miniature "donkey engine" on the locomotive, to work the wheel-work (instead of a spring), which should always be kept in motion, whether the engine be stationary or running. I believe this would also be the cheapest plan. A separate stop-cock would admit the steam to its cylinder. This would only be shut off when the engine was not in commission; and if touched at improper times, the "paper" would at once indicate it, by showing an impossibly short "time," revealed by the other signals marked on the paper; or the proper authorities at the *termini* might turn the "donkey engine" on before the train left, with a

private key. If the paper pass at the rate of six inches per hour, it would be amply sufficient for the purpose.

It would be highly desirable that the guard's van, at the end of the train, should also have a pair of signal wheels, battery, indicator, and bell; and communication could be then effected between the guard and the driver, by means of a small "lever key," whereby the signal wheels of the former could be practically changed in position, by "cross connecting" the wires from them. This "lever key," or "commutator," has a spring, so that it can only be made to act when the hand is kept upon it. The expense of these pieces of apparatus would be extremely small, and the *real* signalling parts having *no* mechanism, it would be all but impossible that they could get out of order. It has all along been assumed that it is necessary for the signal wheels, or brushes, to be in contact with the line. This is not absolutely necessary, although perhaps the preferable method. Peculiarly constructed coils of wire might take the place of these wheels, and simply hang over the insulated rail, instead of touching it. A current must then be flowing continually in that coil which takes the place of the signal wheel in connection with the battery. In each coil, one end of the wire goes to earth. Here the phenomena of induced currents are called into play; one current producing another in a conductor placed near it; also conversely, a conductor with a current passing in it will induce one in a coil approached to it. When this system is employed, the coils must be placed at a small distance one behind the other, in different planes; also further apart, *laterally*, because the "indicator and battery signal lines" must also have a greater distance between them, in order in no case to produce cross currents, or currents in parts of the system where they should not be. There are many beautiful ways of bringing about a visible effect by electricity, without contact between the electrified body and the instrument to be affected; here only one method has been pointed out.

AUTOMATIC SYSTEM FOR STOPPING TRAINS.

If, when a danger signal is set, the train were to be stopped without any interference on the part of the driver, most perfect safety would be secured. This is effected in the following manner:—

The wire, on its way to the electric-bell, passes round an electro-magnet; thus, when "danger" is set, and the bell is ringing, the electro-magnet also is in action, but for so long only as the bell continues ringing. This magnet, when in action, draws an armature towards it, which is thrown back by a spring at other times. When the armature is attracted to the electro-magnet, it pulls out a slide, which is connected with it directly, or otherwise, whereby steam is let into a small apparatus, formed on any suitable plan, such as a cylinder, etc., by means of which, indirectly, the steam of the engine is turned off, and the air-brakes (if any exist) are put on, so that the train stops of its own accord, during the time a danger signal is set. When the armature is attracted, the distance through which it moves is small, since a magnet cannot pull with any force through a long distance, hence it could not directly stop the engine, but would require a smaller apparatus to affect the larger one.

Thus, summing up what occurs when one train approaches within the proscribed limits of another one, assuming them both to be fitted with the most complete apparatus:—

The train behind is stopped, the bell on the engine rings, and the indicator shows "train in front," also having given a ring on *its* bell; likewise these facts are recorded on paper. The bell in the guard's van also rings, and his indicator likewise shows the cause. But in the apparatus on the engine attached to the train in front, and in the brake van behind, nothing occurs but one slight ring of the indicator bell, by means of its needle, which shows "train behind." The electric bell on the engine does not ring, nor is the train stopped.

When the trains are at a proper distance apart again, and the danger signal has ceased, all the signalling apparatus return to their normal condition, and the hind train advances of its own accord, without being influenced by the driver.

Likewise it has been shown that the guard can ring the bell on the engine, and hence *he* can stop the train; the same may be said of the passengers, if there be communication through the whole train, from the engine, with proper handles placed in each compartment; certain penalties being attached to persons misusing them.

CROSSINGS, SIDINGS, AND FACING-POINTS.

The system is admirably adapted for these. At crossings *i.e.*, level ones (for these are all we need trouble ourselves about), the indicator and battery signal lines are to be laid side by side, for a considerable distance from the crossing, and there so connected together, that if *one* train is near such crossing, every other train, and itself, if another should come, will be stopped on approaching this part. A rule of the road might then direct which set of trains shall advance first, so that they may not have to wait indefinitely. But what is far more desirable is, that there should be signal-boxes at these places, with as many single indicators (*i.e.*, indicators with only *one* coil) as there are *sets* of lines crossing (and the signal rails on which the battery signal wheels run, of each set of lines, would be connected with one of these indicators), also a local battery connected with the insulated lines, on which the indicator signal wheels of the engines run; then all trains coming to within a certain distance of the crossing will be stopped, and the indicators in the box will show on which sets of lines the trains are. The signal-man can then signal to all trains on one set of lines "safe" (by breaking the circuit), so that these will advance. When his indicator comes to rest for those lines; then if trains are waiting on other lines crossing these, he signals the same to them, and so on. Or he may make any set "open" in the first instance, by not permitting the local battery to have any influence over that set of rails. By a "set of rails," is here to be understood all those laid parallel. Other plans could be devised, if found more desirable.

We come next to sidings (not with facing-points), and facing-points; although the latter are the more dangerous, I shall treat them on a par. In these cases, there will be a local battery in connection with the insulated line of the siding or loop line. Now, when the "switch" is set to let a train into the siding, the arrangement is such, that the insulated line of the loop is in electrical contact with the signal line of the main line; so that a train approaching would be signalled to and stopped by the local battery. Hence, whenever the loop line is open, approaching trains will be "pulled up." But, supposing this loop were opened *intentionally* to permit a train to pass into it; then by the use of a

second lever, the local battery could be thrown out of circuit and the train would run up and into the loop; for in this case, no danger signal would have been given. A double lever would be more convenient than two levers. One form of double lever is shown in plate 5 appended hereto. Hence, if the siding were left open *by accident*, there is no fear of a train running into it, because "danger" is set. (See figs. 12 and 14.)

ANOTHER MODE OF PRODUCING THE ELECTRICITY.

On locomotives, instead of batteries, electro-magnetic machines might be employed, and the same "donkey engine" before spoken of to work the registering apparatus, could be employed to work this electric current producer also. The electro-magnetic instrument consists, in its simplest form, of an electro-magnet rapidly revolving before a permanent one, poles opposed to poles.

There are many forms of electro-magnetic machines in use, but they are chiefly modifications of the one described, or induction is produced in some other convenient manner.

The current produced by this method being alternately reversed, a self-acting "commutator" is employed to cause the current to flow always in one direction, as is the case with a battery.

In *this* system the ends of the wire of the electro-magnet would be treated just the same as the wires of the battery, had one been employed.

INTER-COMMUNICATION.

There are certain places on the line whence it would be desirable to communicate with a train in motion, especially near stations. If a signal line is laid so that the signal wheel of an engine, which is connected with its indicator, runs upon it, and this line extends to a certain distance from the station, and is connected, by a wire, at this latter place, with a "lever key," placed in the station-master's room, then he can telegraph to the train when it nears his station. Because, if his key goes to battery, and one wire of the latter to "earth," then it is plain, that on depressing his key, (thus

placing his battery in contact with the signal line), a coming train will receive the signal. But how will the driver distinguish this signal from that of "danger"? So long as the key is kept down, so long will the bell of the engine be kept ringing, and the train detained; hence, the station-master can stop a train before it enters his station, if necessary. Then he *intends* his signal to be "danger." Suppose he does not desire to stop the train, but only to send some message? He will then work his key up and down the necessary number of times for imparting his communication. This key is kept from producing continued contact by a spring pressing its lever upwards, which makes it also more easy to work, every depression sending a current.

On the engine of the approaching train, the bell will give one stroke for every successive rapid depression of the key, the needle of the indicator likewise following the movements of the key. No "danger" signal would do this; but the bell would keep on ringing, and the needle having turned to one side, would remain there so long as this signal lasted. The train moreover is not stopped, since, although the steam is, or might be, shut off at each ring, yet it is not for a time sufficient to have effect on the train. Thus the driver would know the message sent by the number of rings on his electric bell. Moreover, in order that the station-master may know when a train is within communication distance, the ordinary signal line may be connected with a "single indicator" in his office.

ACCIDENTS.

The guards of all trains would have with them a portable battery and an "earth key." When an accident happens, such as a landslip, tunnel falling in, or train running off the line, or a mishap whereby the train is thrown from the metals, the guard would attach one wire of his battery to the signal line, and clip the other to an ordinary rail, that is to "earth." Thus he could signal danger to all coming trains.* The "earth key" is an ordinary "lever key," with its wires connected in the same way when in use as the battery wires

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*** The guard could also stop trains travelling in either direction, if required, where there are many lines, with a battery and earth key.**

just mentioned; and in certain situations along the line where a block commences, it might be found useful to signal to trains in front, after the same fashion as a station-master would signal. Speaking generally: at any point a man carrying these two instruments could signal to any train to stop, supposing it were so required. These instruments also give us a method of testing whether the blocks are in good order; two men being employed to walk down the line, block distance from each other, and one applying his key, the other his battery, at the commencement of each successive block, permitting the current to pass through a "single indicator;" this latter instrument is generally called a "galvanometer," and in a certain form a "detector." The guards might also carry this latter instrument with them.

I suggest a method by which every train along a line could be stopped at once, or it might be used as a means of ascertaining, at any moment, if all the blocks forming a line were in good working order. After describing briefly this method, those who are familiar with the modes of testing employed in telegraphy, will perceive how a fault could be detected at a certain spot, without examining the whole line. It is not proposed to detail this method very fully, a general description is sufficient; anyone who has studied the subject will understand it thoroughly from the following short survey, and to others the matter will be tolerably clear, after a little consideration.

The polarised relay will now be described, and then the instruments to be employed for testing the blocks will be understood. The poles of an electro-magnet are caused to be each a north pole or a south pole; here, for instance, suppose north. This is done by placing at the further end of each leg, the north pole of a permanent magnet, thereby inducing a south pole in a contiguous part, (*i.e.* of the electro-magnet) and a north pole at its other extremity. Now suppose the south pole of a balance permanent magnet to lie between these north poles, then it will be equally attracted to each, and therefore rest centrally between them. When the electro-magnet is magnetised by a passing current, it thereby makes a north and a south pole of its own. The effect is to weaken one of its *induced* north poles, and strengthen the other one, so that the free magnet will now be attracted towards the

stronger side, and consequently move towards it.* If this current be reversed, the free magnet will move in the opposite direction.†

Suppose where every block commences and the next one ends, all along the route, there is such an instrument placed; moreover, imagine *always* that wherever a battery is used it is invariably the same pole (*i.e.* zinc or carbon wires) which is put to earth, say for example the zinc pole. Then the magnetic needle of each relay will *always* be moved towards the same side, provided one end of its electro-magnet wire goes to a block signal line and the other to "earth:" *then* no effect whatever shall be produced on the general system. But if at one extremity of the line a "carbon pole" is put to earth and a "zinc pole" to line, then the needles of *all* the relays will move in the opposite direction (in succession,) by a proper arrangement introduced into these instruments, whereby the wires going to earth will be in connection with the next block; and then all the separate blocks are connected into one line, so that, if they are perfect, the current will pass from end to end, and may be made to show itself by means of a "detector." It is also evident that all trains on the line of route could be stopped by this process. Local batteries could be employed where the relays are situated, if desired: thus instead of sending a current from one end to the other, a current may be sent through one block, which causes another current to pass through the next, and so on. But under *ordinary* circumstances this uniting of blocks would not occur.‡

STARTING TRAINS AT STATIONS.

After all that has been said, I deem it unnecessary further to go into minute details, because everything depends on a general system, which once understood, can be expanded to any degree thought desirable. Although much more might be written on the subject, enough has been said for a general

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* Because the north poles of magnets repel each other, and south poles do likewise. But a north pole will attract a south pole.

† There are many other forms of polarised relays.

‡ The relays could not be used unless certain precautions given in Part III. were attended to.

description; but the starting of trains at large stations remains to be briefly considered.

In London, where most Companies have many termini, there might be one central office, with two or three clerks, to work them all. A wire from every line in the stations, and one from every block outside, would be brought to the indicators in this office, and thus it could at once be known on which lines there were trains, and by means of "keys" they could be signalled in and out of the stations. A complete record of the doings of the day could be kept automatically, on a slip of paper; as in the case of a locomotive register. Near stations, the blocks would be short, if many trains were running in and out daily. It might even be thought desirable to have a third signal wheel, or brush, on the engine, passing to an indicator of its own, and thence to battery on earth, *only* to be employed for communication, and to be used only where an insulated rail is so laid as to permit of this wheel to roll upon it. It is not necessary that more should be added on this head, (see fig. 13.)

PART III.

TESTING.

(THE CENTRAL RAIL SYSTEM.)

THE best and most practical method of testing the signal line, would be to allow two engines to run over the whole length of the line, within block distance of each other.

When polarised relays are employed as a means of uniting all the blocks of a line into a continuous signal line, since one end of the wire, on its electro-magnet, goes to a block signal line, and the other to earth, it might be supposed this would destroy the signalling. However, if the resistance of the wire on the magnet be made sufficiently great, not to be overcome by the batteries generally employed, this apparent trouble will vanish. When it is desired to make the relays act, a battery-power great enough to overcome the resistance of *one* relay, together with the resistance of the whole length of signal line, would be necessary; but other ways might be employed. Although the contents of this paragraph may appear simply theoretical to many, yet it is by no means the case, since frequently in electrical experiments this method is employed.

After a current has been sent through the whole of the blocks, for the purpose of testing the signal line, in the manner before described, it will then become necessary to make the blocks again separate. Now, reversing the current at one end of the line will not bring this about; because, after the current has restored the relay of the block nearest

the spot whence the current was sent, to its normal condition, the electricity will pass through this relay to earth; and consequently the current will not disunite the remainder of the blocks. However, trains running on the line would cause, successively, all the blocks to become separate.

The better method to adopt, would be to have a spring in each relay, which should keep the magnetic needle in its normal position. Thus, when a line is being tested, the springs of all the relays along this line will be in a state of tension; and when the testing is completed, these springs, in distending, would again make all the blocks electrically separate. It is also evident, from what has been said, that no inconvenience would be caused by any of these springs getting broken or weak.*

Last, but not least, the engine driver, guard, and other officials in authority, would be able to test the electric apparatus, either daily, as a matter of routine, or when *suspected:* this could be easily done by placing the instruments used on the engine on "short circuit," *i.e.*, allowing the current from the battery on the locomotive to pass through its own indicator; which would be accomplished by means of a "commutator," used only for this purpose. The instruments in the guard's van, and all the apparatus employed in the new system, would be tested in a similar manner.

When the instruments are placed on "short circuit," the current should be permitted to pass through a resistance coil, having a resistance which, if overcome by the current, should show that the battery power is sufficient for signalling purposes.

The commutator used for testing would have a spring, in order that it might always be out of use, except when the hand was upon it for the purpose of testing.

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* Another form of relay might be used without a spring, if desired.

PART IV.

REMARKS ON THE CENTRAL RAIL SYSTEM.

IT would be well to bear in mind that wire brushes might with advantage replace the signal wheels.

There are many ways by which the central rail could be protected, where there are level crossing for horses and carriages. One method only has been spoken of hitherto. Another would be to conduct the signal line (in the shape of an insulated wire) underground at these places, which generally do not exceed a few yards in extent, or to have the frame of the signal wheels hinged in such a manner as to permit of their always rolling on the signal rail, even if this were laid at different levels. The difference between the highest and lowest level of the rail should not much exceed 12 in. Thus the rail at traffic crossings might be laid lower than along the general line of route, and at such places might be protected in a trough.

The "chairs" might be cast in glazed earthenware, to take the place of those described in Part II., if practice should show them to be more desirable.

The signal-rail need not necessarily be placed between the rails, and under the train: at the side of the rails, considerably above the ground, or overhead, would answer the purpose equally well. The system might even be laid partly above, partly below, and partly at the side of the trains; but then a slight modification would be necessary in the character and disposition of the signal-wheels, or brushes.

Each signal-wheel should be broader than the rail on which it runs, to ensure contact, even should the wheel or rail accidently shift slightly.

The signal wheels might have their circumferences grooved, instead of flat, if found preferable.

The following would be a cheap and efficient mode of insulating and fixing the signal rail: wherever a "chair" supports the signal rail, let this latter be surrounded on three sides by a piece of sheet "machine india rubber;" then a wooden wedge would fix the rail firmly in its place. The upper surface of this rail would, of course, be the side not covered by the india rubber. "Machine rubber" is very cheap, tough, and durable.

Of course, the conductor joining a signal wheel with its instruments, could not be an insulated wire attached *directly* to it; but there is no reason why it should not be attached to the part which supports the axis of these wheels; when the current will first flow through the axis, then through its bearings to the wire. Or one of the many means now in use, may be employed for securing good electrical contact between a revolving wheel and a stationary instrument.

Here we encounter certain apparent difficulties, viz:— When a conductor is heated, it loses a very large portion of its conducting properties: thus will the signal wheels, or their axles, ever become sufficiently hot to offer such a resistance to the passage of the current as to render them practically useless? Answer—No.

Secondly.—Since the axles are greased, will the grease act as a non-conductor between the axles and their bearings? Answer—No.

The reason for the reply given to the first question needs explaining.

Neither the signal wheels nor the axles would ever become hot enough to injure their conductivity: *because* the diameter of these wheels would be of a fair size, and the axles kept cool with grease.

For the electro-magnetic stopping apparatus on the locomotives, a local battery (*i.e.* on the engine) with a relay might be employed.

Instead of employing the automatic stopping apparatus a danger signal might be given; when the driver would turn off the steam, and apply the brake.

In the event of a heavy fall of snow, an engine with a brush could clear the central rail (were this employed); or the rail might be laid at such a level that if the snow reached it, trains themselves could not run.

Dry snow is a non-conductor, but wet snow conducts electricity.

It might be supposed that when the current enters the differential indicator on the locomotive, the current having traversed one coil, will then split "to earth," and through the other coil. This effect would occur, and thus destroy the action of the indicator, were it not that the resistance of the earth is practically zero, as compared with that of the coil. Experiment bears this out.

PART V.

WIRE METHOD.

IN this part, the most practical modification of my system will be described. The wire method was hinted at in the appendix to my last pamphlet; but believing it to be worthy of a full description, I give it here, and append some plates, to render the subject more clear to the reader. It is only intended, in this part, to treat the method briefly and concisely, so as to convey a general idea of the system. In Parts VI. and VII. its details will be more fully dwelt upon. This mode of proceeding is calculated to make the subject easier of comprehension.

THE SIGNAL LINE.

THE signal line would consist of a metal rail, having any suitable section, and laid by the side of the rails on posts, 5 or 6 feet above the ground, at the commencement of the blocks. (See fig. 6 and 7 B C D) This rail might even be replaced by a wire. (See fig. 10.) The signal line would be laid in three sections or portions, one after the other, in the direction of the permanent way. (See fig. 7 B C D) The engine would carry a battery, a single galvanometer, and a bell. The automatic stopping apparatus might be added, if desired, together with the other accessories already described.

There would be a wire brush, so placed as to come in contact with the signal line, wherever this were laid.

The "circuit" is as follows:—

One pole of the battery is put to "earth," by being attached to the locomotive; from the other pole, a wire passes through the bell and galvanometer to the brush. Thus, were the brush upon a signal line, and the latter put to "earth," a current would pass, which would cause the bell to ring, and the needle of the galvanometer to deflect.

The first section of the signal line is the one on which a signal would be received, and should, therefore, be laid for a distance equal to that in which a train might be stopped, going at a high speed, or the highest speed which is permitted at that portion of the line where the signal line would be.

The second section of the signal line would be for the purpose of shutting the block against all coming trains, which would be accomplished by simply placing the first section of the line to "earth."

The third section would unset the preceding block, in order to allow a train to pass into it. How this "setting" and "unsetting" would be effected will presently be described.

Let us call the first section of the signal line the "signal rail;" the second section the "closing rail," since its function is to close the block; and the third section the "opening rail," since the action of this one is to open the previous block. Between the ends and commencements of the blocks would be an ordinary overhead telegraph line, in order that there should be a communication between the "opening rail" of the one block, and the "signal rail" of the previous one. At every block there would be a signalling apparatus, which would consist of a Hughes' differential relay.* (See fig. 7 A A A) The "closing" and "opening" rails need only be laid for a few feet. The bell would ring whilst the brush was passing over the "closing and opening rails," whether the block were closed or open, but only for an instant, since these rails are very short. If this is considered to be undesirable, it would be an easy matter to alter this arrangement, by a method described in the next part. However, I believe it would be an advantage to the engine-driver to know when he has entered a fresh block, and that he has passed the "signal rail" without a warning. It would also be a means of testing at every

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* **For best form of signalling instrument, see Part vii.**

block whether his battery were in good order. But when the brush is passing over the "signal rail," the bell would continue ringing, if "danger" were set.

The Hughes' differential relay* consists of a horse-shoe permanent magnet, with two coils of wire upon each arm, the wire of one coil on each arm being continuous with the wire of one coil on the other arm, forming, as it were, two electro-magnets in one.

The wire in one pair of coils is wound the reverse way to that on the other pair. Now, supposing the "horse-shoe core" were only a piece of soft iron: then, if a current were passed through one pair of coils (*i.e.*, one wire), the "core" would become magnetised, one arm becoming a "North pole," and the other a "South pole." Then let the current flow through the other pair of coils (*i.e.*, the other wire), the result will be the same as before, but the polarisation would be reversed: that is, the "North pole" in the last experiment would now become a "South pole," and the former "South pole" a "North pole," because the wire on one pair of coils would be wound in the opposite direction to that on the other pair.

We will repeat these two experiments, but we will this time suppose that the horse-shoe is a permanent magnet, and therefore it will have one arm *always* a "North pole," and the other a "South pole." In this case, when a current is passed through the coils which would produce an *independent* "North pole," in the arm which is *already* a *permanent* "North pole," the effect would be to *strengthen* this pole. The same effect would be produced on the "South pole." Hence the magnet would be considerably strengthened; for we have the core a permanent magnet at starting, and to this we have super-added the magnetism produced by the current circulating in the coils. Now, if we pass the current through the other pair of coils, we should find the permanent magnet would be much weakened; for the tendency, in this case, is for the current to induce opposite poles in the arms of the horse-shoe to those already existing there. In fact, the current, in this case, *tends* to demagnetise the core.

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* Perhaps this instrument should more properly be termed a differential polarised relay.

This completes the description of the Hughes' differential magnet; and now it is necessary to explain its use.

Suppose an armature were placed over the poles of the magnet, on a hinge at one end, and held off the poles by a spring, having just sufficient power to overcome the attraction of the permanent magnet, when no current is passing through either pair of coils. Now, imagine a current to be sent through the coils which strengthen the magnet, then the armature will be drawn down to the poles of the magnet, since this latter is now made powerful enough to overcome the spring. Moreover, when the current ceases to pass, the armature will remain held down, because it is in close proximity to the poles of the permanent magnet, which attract with continually increasing strength as they are approached; in other words, although the magnet could not *draw* the armature *down*, yet when it is *down*, the magnet will *hold* it there.

If we now pass a current through the coils which weaken the permanent magnet, the spring of the armature will have the balance of power in its favour, and the armature will leave the poles to assume its former position. It will be seen the spring requires to be carefully adjusted, although the limits for adjustment are very wide.

It is evident from what has been said that by simply passing the current through the one or the other wire of the coils, we can draw down the armature to the magnet, or release it, at pleasure.*

This instrument is employed for signalling, as follows:—

One end of each of the coils is taken to "earth;" the other ends are connected respectively to the "closing rail" of the block where the instrument is stationed, and to the overhead line which goes to the next front block. (See fig. 7, A C and overhead lines.)

The hinge of the armature is connected with the "signal rail." (See fig. 7 A B.)

When the armature is "down," the *free end* rests upon a screw, which is connected to "earth." (See fig. 7 A A).

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* **Many forms of the signalling instruments are given in Part vii., as well as the most sure and delicate methods of working the Wire-system.**

One end of the overhead line goes to one pair of coils on the magnet, as explained above, and the other end goes to the "opening rail." (See fig. 7 D.)

The coils which are connected with the overhead lines are those which weaken the permanent magnet, when a current is passing, and consequently the coils in connection with the "closing rail" are those which strengthen the magnet when they are in use.

Hence, supposing one pole of a battery taken to "earth" in each of the following experiments, and the other pole applied, firstly, to the "signal rail," then no effect will follow, because this rail is connected with the armature of the signalling apparatus, which being *up*, is not resting upon the screw which is put to "earth." Secondly, apply the pole of the battery to the "closing rail:" a current will now pass through this rail to and through the coils on the magnet, which strengthen it; thence to "earth." Therefore, the armature will be drawn down and kept there, and consequently it will be resting upon the screw, which is "to earth," thus giving an "earth" to the signal rail. If the first experiment were now to be repeated, a current would be found to pass. Lastly, let us apply the same pole of the battery to the "opening rail," a current would pass into the overhead line, and to a pair of the coils on the signalling instrument of the preceding block, these coils being those which weaken the permanent magnet when a current traverses them; thus, were the armature to be *down* at this block, it would be released, removing the "earth" given to the "signal rail" at that block. (See fig. 7 and 16.)

What has just been described is the whole process of signalling, as automatically done by a train in motion.

First: The brush, in connection with a battery on an engine, brushes over the "signal rail;" suppose this is not "to earth," then no current will pass; the brush then passes over the "closing rail"; which causes the "signal rail" to be put to "earth," and any other train which might attempt to enter that block will now receive a signal.

When the brush crosses the "opening rail," the effect would be to remove the "earth" of the "signal rail" belonging to the previous block, in order to open it to any

coming train; this block having been previously closed by the train when it entered it.

It is thus seen that no train can come within block distance of another, and that the process of signalling is automatic and certain. A summary of the process is: The train, on entering a block, firstly receives its signal, then closes the block, and lastly opens the one it has just traversed.*

ACCESSORIES.

THESE would be exactly the same as in the Central-rail System, with the exception that the indicator would be single, and only signal when there was a train in front, which is all that is required.

A modification of the indicator is shown in fig. 11, which will be explained hereafter.

AUTOMATIC SYSTEM FOR STOPPING TRAINS.

CROSSINGS, SIDINGS, AND FACING POINTS.

ANOTHER MODE OF PRODUCING THE ELECTRICITY.

INTERCOMMUNICATION.

ACCIDENTS.

STARTING TRAINS AT STATIONS.

IN describing the "Wire System" it is unnecessary to describe again in detail the subjects denoted by the above five headings, since they have been discussed when explaining the "Central-rail" System, and the remarks made there apply equally to the "Wire Method." There will be some further explanation of "Crossings," "Intercommunication," and the "Starting Trains at Stations," in the next part, when figs. 13, 14, and 15, are described.

TESTING.

THIS would be very simple. An engine sent along the line might accomplish it. The overhead lines might be tested by any of the methods adopted by telegraphists, or the signal-

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* Various modifications of the signalling process are given Parts vii. & viii.

ling instruments might be tested singly by pressing down and releasing their armatures by hand.

In general, the overhead lines alone will require to be tested, and these only occasionally. If the modification, detailed in Part vii., were employed, then the usual polarised relay tests could be applied.

PART VI.

THE PLATES.

THE plates are arranged on the sheet in groups according to their subjects, and therefore it will be necessary, in describing them, to jump from one figure to another without reference to their order, since it is intended to make the explanation at the same time a description of the system.

Figures 1, 2, 3, 4, 5, have already been explained when describing the central rail system.

Figure 8—Shows a method of mounting the central rail
A, A, A, on "sleepers."
E, E, E, the "chairs" supporting the rails.
D, D, D, the "chairs" supporting the central rail.

Figure 9—Represents the end view of one chair supporting the "central rail.

N.B.—It may be seen from the diagram that the distance of the rail above the ground is regulated by the height of the rail between the "chair" and "chair fixing."

It is also to be observed that the zinc weather protector effectually covers the insulating parts.

Figure 6—Illustrates the method of mounting the rail under the "wire system." This way of mounting may likewise be employed for the "central rail system."

Fig. a—A A, the rail; B B, rings for connecting the rails together.
C, End view of rail, showing one ring.
D, Connecting bar; E E, nuts; F, end view of a nut.

Fig. b—End view of rail mounted.
B, Weather protector of the post.
G, The post; H, the rail; I, nut on connecting bar.
I, Also refers to the porcelain insulator.
J, Insulator unmounted, dotted lines indicating a hole for a bolt to attach it to the post; as shown at G.

Fig. c—Rail mounted, side view.
O O, rail; L, post; N, connecting bolt; M, insulator.

Fig. d—Represents the wire brush, carried on the engine.
K, the guards.

Fig. e—Various sections which might be employed for the rail.

Figure 10—Represents the arrangement of the "signal rail," were a wire employed instead of a rail.
A, support; B, insulator; C, post; (the ring in A shows the section of the wire).
The dotted line illustrate the mode of fixing. These bolts are in different planes.
D and E, two forms of brushes; F, another form of contact.

Figure 7—Almost speaks for itself; it represents the "wire system" laid.
The bank is shown as it might be at any portion of a railway line.
B C and D represent the "signal, closing, and opening rails" respectively, and the dotted lines show the connections.
C and D are drawn out of proportion, since these are so short that a dot would have represented them in the figure, had they been drawn to scale.
A is the signalling apparatus.
h, the armature rings; *n*, the armature.
g, the springs; *a*, the "earth resting pin."
The connections are shown by B *b*, C *c*, and D *d*.
The length of the blocks is shown below.

Figure 11—Illustrates the modification of the indicator whereby a model semaphore would give the signal. The dotted lines show the interior, and the large dots the connections.
A, the bell; B, the hammer; D and E the terminals; one wire from them being put to "earth," and one connected with the brush.

1 and 7 Electro-magnets; 8 8 8, Leclanché cells.

Z and 6, armatures; 3 A, springs; 4 A, lever; *c*, the semaphore.

This instrument is represented in a simple form to show its construction at a glance. In practice, only one magnet would be employed to act as a polarised relay, to ring the bell, and to work the semaphore.

Figure 12—Represents a siding lever.

A, the lever; B, the signal lever; *c*, the stop to prevent pulling B too far; D D, the supports of B; E, the spring; H, the hinge; M, the attachment of the wire I; N, a piece of ebonite to insulate I from the lever; I, is connected with the signal rail; J, is the spring on which M rests, when the siding is in communication with the main line, as shown in the figure; K, the fixing point of J; L, the wire connect ing the battery with K.

Thus when the siding is open for a train to enter, as here shown, and no one near the switch, a train cannot enter, since the local battery is in connection with the signal rail, and this latter is in connection with the main line signal rail (because L is in electrical continuity with I,) and therefore an approaching train would receive a danger signal.

However when B is drawn up, a train will receive no such signal, since the local battery is now removed from the circuit, as seen by reference to the drawing. When the siding is out of use the lever is thrown over in the position of the dotted line.

The levers now employed would only require the portion B added to them.

The stop *c* might be a screw, by using which the lever B might be kept withdrawn, so that the siding could be left (electrically) open to the main line, without requiring any one to be present, if this were desired.

Figure 13—Represents the arrangement to enable a station-master to communicate with a moving train.

The station is supposed only to have a single line through it in order to make the drawing simple.

The arrangement is shown for the central rail system.

By observing the connections (the dotted lines) it will be perceived that an approaching train reports itself upon the galvanometer, and would likewise cause a bell to ring, if this instrument were added, and it will also be seen that the station-master can telegraph by means of the key.

A slight modification would be required under the "wire method," viz: since there is but one rail (although two might be employed), this must accomplish all the signalling; hence the key and galvanometer would be in the same circuit, and the key would be a double acting one, so that when it is not in use, it would give an "earth" to the galvanometer; and when in action the "earth" is exchanged for the battery. In fact, the double acting key is no more than the usual telegraphic "double current" key, only "connected up" in a different manner.

Figure 14—Represents a crossing, (one pair rails in each set.)

The ordinary rails have been omitted here as well as in figure 13. It will be perceived that the connections are similar to those in figure 13, only double, since there are two lines of rails; hence, this is likewise the arrangement for a station with two sets of lines running through it. It is also to be observed that if there were more lines, it would require the same arrangement as in figure 13, multiplied by the number of lines.

A method for the regulation of crossings has already been described where no signalman is required.

Figure 15—Shows an instrument which would be placed in an office at any large station, whereby one man could work all the trains *in* and *out* with ease and certainty.

For an example, the instrument shown here is the one which would be employed at the South Eastern Station at Charing Cross.

The instrument itself has a plan of the rails in the station and a short distance out of it, upon the dial. Here for instance, the block C is the plan of the rails in the station, and block A the plan of those on the bridge, across the Thames. If desired, another block further on might be added. The short blocks B apply only to the engine

sidings. The numbers on the dial refer to the lines beside them, and to each portion there is a galvanometer needle, which deflects when there is one or more trains on that portion. It is supposed in the figure that there are no trains upon any of the lines. P P P show the positions of the platforms. The keys are numbered, to correspond with the portions of the line to which they are connected.

Hence, one thing is clear: a clerk, at a glance, can see the position of every train in or near the station; and, further, he can communicate to any of these trains. There would be a locking system in connection with the keys, whereby the clerk would be prevented from pressing down any keys which might cause a collision. Likewise, every act of pressing a key down would be reported on paper, as well as the time of day when this was done, by a process similar to the register described for use on the locomotives. Where a single key is shown on the figure, A is the knob, D the contact, B a spring, E the support, F the board, C the lever, and G the "registering and locking pin."

We must now see how the following functions would be performed:

1. Signalling to a block when many trains are upon it.
2. Working the switches.

It is well to observe that the instrument shown in fig. 15, only consists of a number of galvanometers arranged systematically in one instrument, for the sake of convenience; and it is therefore no more than a series of the arrangements shown in fig. 13.

Suppose there are many trains within a block, and suppose they all require to enter the station, then as every train upon that block would receive the signal to enter, it is plain that it would only apply to the first train; but, as on line 2 there might be two trains, both of which could start by running on to the next line, the clerk would then telegraph which train should start first. These remarks apply equally to trains going *out*.

Secondly, it is clear that the switches would continually require shifting. There are many ways of accomplishing this:

1. By placing in the "lever box" an apparatus similar to fig. 15, without a key-board, and from this a man would read which lever to move.

2. To place an indicator over each lever, to show which one should be used.

3. To make the switches act automatically, by means of weighted levers; so that a lever would drop when a current passes through the instrument which would release its weight, and this latter would afterwards be replaced by human agency.

4. To accomplish the setting as in the last case, but in lieu of employing a man to replace the weights, to let it be done by another (heavier) weight, which would occasionally require winding up, and when this latter were three-quarters down, it would announce the fact by ringing a bell in the clerk's room.

In each of these four cases, the instruments in connection with the respective switches would be in the circuits of the corresponding keys in the clerk's office.

It is also to be noticed that electric bells could be introduced at any place where it might be thought desirable.

From the foregoing remarks it is clear that one man could work a large station, with the utmost ease and certainty; moreover, the expense would be small, the machinery simple, and the signalling rapid.

Figure 16—Represents the form of signalling instrument which was described in the last part. Every portion is named in the figure.

Figure 17—Shows (in plan) some of the methods for laying signal rails under the "wire system."

In the first way there would be two brushes, one to receive the signals, and the another to close and open the the blocks, in which case the bell on the locomotive would only ring if a block were closed.

The second manner of laying these rails is to close the block, and open the previous one in a single operation.

The third method shown, is the one already described. Other ways are possible.

PART VII.

REMARKS UPON THE "WIRE SYSTEM."

THERE are a few observations which I deem it necessary to make; and being of considerable importance, they are given together here as a separate section.

The form of signalling instrument already described is not the best for practical use. The reason for choosing it for illustration, in Part v., was that I thought it the best to explain the system upon. The following, however, are some of the most desirable modifications of the signalling apparatus:

Instead of a Hughes' differential magnet, two ordinary Hughes' magnets, or two ordinary electro-magnets, might be employed, since there exist two distinct circuits.

Since a spring is often considered objectionable, because its strength varies, and it therefore at times (although seldom) requires readjusting, it might be dispensed with, and either a gravity armature might be employed, or an armature on the polarised relay system.

There is no surer system for working any electrical instrument than the polarised relay method, which may be regarded as truly infallible; and I should strongly recommend the whole of this system, as well as the Central-rail System, being worked with or upon the principle of these relays.

The main advantage of the "wire method" of signalling is, that the signalling instrument may be reduced to the form of a double polarised relay, the result being *certain* action, since it will work with the merest trace of current, *and reduces*

correct signalling to as much of a certainty as the expectation that the sun will rise again in the East after it has set in the West.

Another great advantage is, that the batteries may be allowed to become extremely weak before they require to be recharged.

A moderate estimate for the duration of time of the working power of a battery (Leclanché) would be *twelve months,* so that if these were changed twice a year, no fear whatever need be entertained as to their failing, supposing the batteries to be in daily use.

From the above advantages, two more important ones result. These are, that *one or two cells* would be ample to accomplish the signalling with absolute precision, and *one cell* would work all the apparatus on the locomotive. Consequently, *three or four* cells would be all that any engine need carry. And, secondly, the resistance of the circuits is almost a vanishing quantity. Four ordinary (No. 3) "Leclanché" cells measure no more than 8 inches by 5 inches by 6 inches.

It is, perhaps, desirable that "Lightning-plates" should be used in conjunction with the overhead wires, as is generally done in telegraph offices, notwithstanding that the resistance of the circuit is small, compared with that of telegraphic apparatus, in order to secure *perfect* freedom from the destructive effects of lightning, which sometimes burns the wire when these "plates" are not employed. Often in needle-instruments the lightning demagnetises the needle without injuring the wire, but this class of accident cannot occur in this system since no magnetised needles are essential to it.

PART VIII.

GENERAL OBSERVATIONS.

IT has been explained how a station master could communicate with a train in motion, but nothing has been said about the engine driver signalling to stations or to other trains.

It is well to observe that this might be accomplished by placing on the engine a lever key, whereby a current could be sent into the signal line on which the indicator signal wheel runs. This signal line could thus be made to act like a telegraph wire between the station and the train.

In the same manner the engine drivers of two trains could signal to one another at all the important places along a line, since the indicator signal line is continued for long distances at such places.

When sidings lead nowhere, there need only be a local battery, (the use of which has already been explained,) and the signal rail of such sidings may be dispensed with.

The indicator has been described with *one* magnetic needle, balanced in the centre of the hollow coils, capable of being influenced by a current passing through either coil. To make this instrument very sensitive, *two* magnetic needles fixed on the same axis could be employed. It is necessary these needles should not act astatically. In this case, there would be one magnetic needle in the centre of each coil.

The engine driver might be completely protected against the weather, since he would not require to look out for signals placed by the side of the line.

Signal rockets might also be employed to announce an accident at a distance; and their colours and loudness might even indicate the nature of the mishap. It is surprising that such have never been employed.

The whole of the additional apparatus, (except the signal wheels,) might be fitted in a box, which would only require fixing to the engine; when the "unions" would be screwed up, and the wire attached to their continuations. The signal wheels or brushes might be manufactured complete, in a frame; then this would only require fixing in front of the engine on the plate to which the "buffers" are attached, or elsewhere. Hence the time occupied in altering a locomotive, for the new system, would be very short.

It is to be observed, that the signalling by the central rail method is on the same principle as that of the present system, viz.: the normal state of the signals is "safety." Much has been said of the advisability of making the normal state of the signals "danger;" however, this has not yet been adopted. This system could be modified so as to meet this requirement, if desired, by placing at the entrance of each block a suitable piece of mechanism.

At present, a train is signalled before it reaches a station; in the new method of signalling, this would also be done. The fact that the train had come within communication distance of a station, would cause an electric bell, placed in the circuit there, to ring.

Should a train, perchance, leave the metals, methods of stopping all coming trains, have been described. One was by employing rockets, and the other the use of a battery by the guard. Other methods are possible: of which the best is, to make the battery, which is in connection with a signal wheel, automatically clip itself to the rail, in case of such an accident.

Many simple mechanical contrivances could accomplish this; because in the above-mentioned kind of accident, a force suddenly comes into play, which has a direction different from that in which the train was going.

Local batteries at the blocks, or in other localities, might be found useful, either alone or with simple or polarised relays.

Double currents might be introduced if found desirable.

The duplex system could also find a place in the system.

Heat, produced by electricity, or by some other means, might be employed to give the signals. In this case, the signals would be rendered visible by the intervention of wires or compound bars, or by the simple expansion of a solid or liquid, or the burning of a wire, or even the rendering of a body a conductor by the heat.

Hughes' magnets, either simple or differential, might be introduced into the system.

Mechanical, combined with electrical, magnetic, or electro-magnetic contrivances might sometimes be found convenient.

It has, so far, been supposed that there have been two signal wheels on the engine and two on the guard's van. Now when a current from a train in front affects an engine's indicator, the electricity passes to earth; then how can this current affect the guard's indicator? The answer is plain, although, if there were none, the question would appear to to take away one of great advantages of the system. The resistance of the signal line, between the engine's signal wheels, and those of the guard's van, may be almost disregarded; but it may, however, be allowed for by slightly diminishing the resistance of the instruments, in the van, by increasing the thickness of the wire in the apparatus, or by employing a better conducting wire, or by shortening its length.

Now when a current from the battery on an engine (after passing through the signal line,) meets the signal wheel of a locomotive on a train behind, it finds two courses to earth: one through the indicator on the engine, and the other through the indicator in the van. But since the resistance in each of these courses is *nearly* equal, the current will "split," and pass half by each road to earth, thus affecting both indicators.

It is by no means necessary that the signal wheels should be always used in pairs; for if the engine only had the signal wheel which is in connection with the indicator, and the guard's van the one which is connected with the battery, it is

obvious that the signalling would be as perfect as when the signal wheels were employed in pairs. The objects for having two signal wheels, are as follows :—

1.—To secure perfect signalling even when an engine has no train attached to it, and consequently no guard's van.

2.—To secure better safety.

When a train is drawn by more than one locomotive, or has many guard's vans, the various apparatus on all these will act harmoniously and coincidently together, as will be understood from the considerations already placed before the reader.

Suppose one of the signal wheels were to break; the result would not be to impair the signalling, because *both the engine and guard's van* are fitted with such wheels. As an extra precaution, however, each engine might carry a spare wheel, or brush, if these were employed.

There are often peculiarities at certain places along the line, which would require a slight modification of the system described, not because it is actually necessary, but because it might be found more convenient.

The following are a few modifications on which this new system might be worked :

1.—By having a local battery in connection with each block, and no batteries on the engine or guard's vans.

2.—By employing the local batteries, and likewise batteries on the locomotives and vans.

3.—By making use of both poles of the batteries, instead of always employing the same one.

4.—By employing one of the ordinary rails for the signal rail, having insulated it first. However, there are numerous objections to this method.

The above four modifications of the system, to which twenty-two others might be added, are only very briefly described; since their full development could be perceived with a little thought.

Two points are worthy of remark :—Firstly, that by employing the method detailed in Part II., the present block

telegraphic wire might be used for general communication. Hence, in calculating the expense of laying down the signal line, the value of this wire should be deducted.

Secondly, if the wire modification were used, then the present block telegraphic wires could be employed. Moreover, on this system, the normal state of the signals would be the *equivalent* to "Danger."

Any accident to the signal-lines, whether rail or wire, would simply cause *delay*.

This system is not liable to accidents arising from lightning, since magnetised needles are dispensed with.

Great delay and narrow escapes have occurred, under the block-system, from the demagnetising of needles, which renders the telegraphic instrument, commonly employed, useless; and the block-system may be said to be entirely dependent upon telegraphy.

It can easily be seen that the new system is adaptable for every emergency which can exist upon any railway, whether a "heavy" or a "passenger" line.

Finally, I have heard persons make the remark that this system seems marvellous, and so delicate, even if possible in practice, as to be almost a fiction. But on reflection it will be seen that there is nothing more than a suggestion as to the best mode of constructing *a moving telegraphic office*. If between two telegraph stations (one being placed upon wheels) we were to commence rolling up the wire which joined them, the effect would be to approximate the offices; the one on wheels being drawn towards the other. To advance a step further: instead of rolling up the wire, we might push our moveable office towards the other, continually cutting off the wire left behind it; or, lastly, we might have a wheel, (connected electrically with the telegraphic apparatus,) rolling upon the wire, as the office is advanced, and then the same result would be attained, viz: continual communication between the two offices, although one would be in motion. The same effects would also occur if both offices were upon wheels. The new method of automatic electric signalling is no more than this, modified to suit circumstances.

PART IX.

DISADVANTAGES OF THE BLOCK SYSTEM.

THE disadvantages of the present system of signalling may be summed up as follows :—

1.—The overworking of the signal-men : possible mistakes from the continual strained attention required of them : sudden illness seizing them : drunkenness.

2.—The complication of signals required at large stations.

3.—The foggy weather dangers.

4.—The difficulty of distinguishing colours when the eye is long tried.

5.—The non-observance of signals by drunken, careless, or fatigued engine drivers.

6.—Colour blindness of the driver.

7.—The danger of accidents arising from the magnetic needles of the telegraphic instruments, commonly employed, becoming demagnetised by lightning, thus rendering the apparatus useless.

8.—The difficulty in most cases of ascertaining the cause of an accident.

9.—The very small check for the discovery as to with whom the fault lies, when accidents happen, or trains are unpunctual.

10.—The long levers often employed, where signals are at a distance from the box, especially where sharp curves occur in cuttings.

11.—The great length of wire ropes often used. In this, as well as in the last case, there is possibility of slackening, bending, or breaking.

12.—The danger of facing-points and crossings.

13.—The loss, for general purposes, of the telegraphic wires connecting the signal-boxes.

14.—The impossibility of station masters communicating with trains.

15.—The same in respect of one train with another.

16.—The almost certainty of an accident, when a landslip occurs, after a train has past its signals.

17.—The danger to which men working on the line are exposed.

18.—The frequent loss of life, and injury done to persons in an accident.

19.—The expense of the men engaged at the signals, the fuel during the winter; keeping the signal-boxes and mechanism in repair.

20.—The expense of trimming lamps for the night service.

21.—The great responsibility of the directors.

22.—The small dividends in consequence of these expenses; and when accidents occur, compensation due to injured parties, and damage to rolling stock, etc.

Many other disadvantages might be shown, but the above are the most striking.

The new plan places all these "out of court," besides introducing numerous other immense advantages; and from its simplicity no trained persons would be required to work it.